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Improvement of Setup Time and Production Output with the use of Single Minute Exchange of Die Principles (SMED)

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Abstract— ***Single Minute Exchange of Dies is a tool to enhance the Overall Equipment Effectiveness as it increases the equipment availability. The automobile industry is an essential part of the economy where these are of vital importance, hence, the need to carry out this study in an automobile equipment manufacturing organization.***

Keywords— **SMED – Single Minute Exchange of Dies, Internal Activities, External Activities, Setup of a Centerless grinder**

I. Introduction

Single Minute Exchange of Dies (SMED) was developed by Shigeo Shingo in the 1950's in Japan in response to the emerging needs of the increasingly smaller production lot sizes required to meet the required flexibility for customer demand. The study was originally developed through the study of a die exchange process [1]. Generally, SMED aims at standardizing and simplifying operations. By this means, the need for special skilled workers is also minimized. The SMED technique is used as an element in Total Productivity Maintenance (TPM) and Continuous Improvement Process in various studies to reach lean manufacturing [2-5]. [6] According to Maryland Technology Extension Services MTES, "Lean is a team based approach to identifying and eliminating waste (non-value-adding activities) through continuous improvement by following the product at the pull of the customer in pursuit of perfection." John Shook who introduced TPS in USA in 1980s defines Lean as a "manufacturing philosophy that shortens the timeline between the customer order and the shipment by eliminating waste". Lean production is aimed at elimination of waste in every area of production including customer relations, supplier networks and factory management. Its goal is to incorporate less human effort, less inventory, less time to develop products and less space to become highly responsive to customer demand while producing top quality product in the most efficient and economical manner possible. Two categories of waste can be discerned as original form or waste and new form of waste for an understanding of the emerging need for approaches such as Lean for improved performance.

II. Material and Methodology

The study followed a meticulous observation process that employed both manual and digital processes - a Video recording of the different runs of the machine was analyzed. There are seven basic steps which were used to reduce the setup time using the SMED system (refer fig):

1. OBSERVATION of the current methodology (A).
2. Separation of the INTERNAL and EXTERNAL activities (B). Internal activities are those that can only be performed when the process is stopped, while External activities can be done while the last batch is being produced, or once the next batch has started. For example, go and get the required tools for the job BEFORE the machine stops.
3. CONVERSION (wherever possible) Internal activities into External ones (pre-heating of tools is a good example of this).
4. STREAMLINING THE INTERNAL ACTIVITIES, by simplifying them. (C)Focus on fixings – It was rightly observed that it's only the last turn of a bolt that tightens it - the rest is just movement.
5. STREAMLINING THE EXTERNAL ACTIVITIES, so that they are of a similar scale to the internal ones. (D)
6. DOCUMENTATION of the new procedure, and actions that are yet to be completed.
7. Repeat: for each run, a 45% improvement in set-up times may be expected, so it may take several iterations to cross the ten minute line.

A bay of the shop floor was chosen for experimentation and implementation. The setup operations of all the machines in the chosen bay were observed and the time taken for the setup of each machine was noted. After the observation of the setup timing of each of the processes, it was noted that the Centerless Grinding machine was taking up the most amount of time (120minutes), hence, this machine was shortlisted for the experiment. The details of the setup process on the Centerless grinder were observed by a method in which each process of the setup operation of the Centerless grinder was recorded on a video camera and then loaded onto simulation software called the VISIO Timer Pro Professional software which offers a low cost Excel based solution for those involved in process improvement, lean and kaizen initiatives based on the principals of the Toyota Production System to identify and eliminate non value adding work content. A video of the process in concern is recorded and loaded on to the software. The total time consumed by each activity is broken down into smaller bits after which the SMED process was applied on each of the broken down timings. Each bar represents the task performed by a single operator. Each task is made up of a series of activities represented by the chips in the bar. The height of the chip is proportional to the time for each activity. The color of the chips represents whether the activity is value added, non-value added or required but non-

value added work. Each chip has a video attached that can be played to see the correct method of performing the task.



Fig. 1. Screenshot of the Timer Pro Professional Software

III. Results and Tables

A system of SMED called the ECRS was used as a basis for the experiment. The table 4.6 shown below defines the process.

E – Eliminate: This process suggests that all unwanted motions, movements and activities be eliminated such as: looking for tools, setting up of the machine, entering the program on the machine.

C- Combine: This process suggests that a few of the process can be combined (performed along with another process) in order to save time. For example: Loosening of bolts (Screwing and unscrewing), entering the program onto the machine can be carried out at the same time as another activity.

R- Reduce / rearrange: This involves the reduction of a few activities like extra turns of bolts etc.

S – Simplify: This process suggests that complex processes can be broken down and simplified, combined and rearranged to save time.

Each sequence was observed and the times that are involved in making mistakes, searching for tools, shortage of materials, inadequate verification, which can be avoided by the use of a tabular columned frame work containing a list of all the required tools and materials were estimated and suggested to be eliminated. This tabular frame work is called a **'Check Table.'**

The processes that involved extra time, like extra turns of bolts, entering of programs into the CNC machines after the work has been loaded and waiting for equipment to arrive, were estimated and suggested to be reduced by various methods which have been suggested later in this write up.

The processes that were consuming extra time either because they were being carried out by a single worker, like loading and unloading the work from the machine, or a single process is broken down into two or more processes – first inserting the bolt and then turning them, were estimated and suggested to be combined, either to be performed by two operators at a time or in case of processes, two or more similar processes to be carried out in combination with each other to save time.

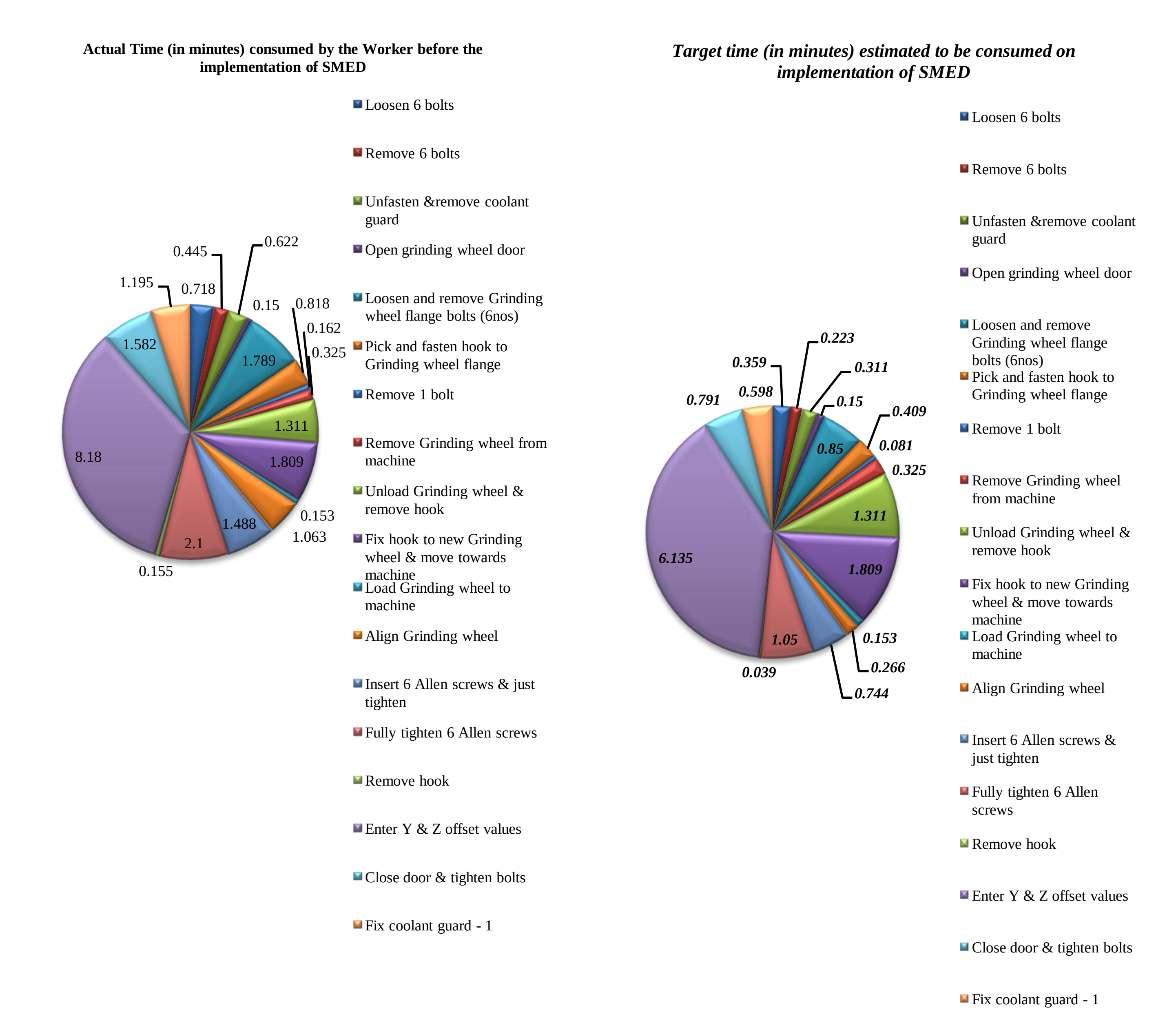
The processes that were consuming a lot of time because of their complexity, like methods used in the fastening and unfastening of bolts, were estimated and suggested to be Simplified by various methods

The following table illustrates the observations made after the implementation of the SMED process. Observing the process in the operation of the machine under study, the following data were recorded.

TABLE I. OBSERVATIONS MADE AFTER CARRYING OUT THE SMED PROCESS

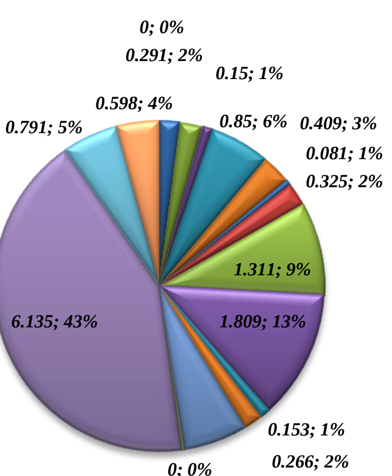
Sl. #	**Task/Operation**	**Actual time (minutes)**	**Target time (minutes)**	**ECRS**	**Time saved (minutes)**
1	Loosen 6 bolts	0.718	0.359	**Combine and Simplify**	0.291
2	Remove 6 bolts	0.445	0.223		
3	Unfasten &remove coolant guard	0.622	0.311		0.311
4	Open grinding wheel door	0.150	0.150		0.15
5	Loosen and remove G/wheel flange bolts (6nos)	1.789	0.850		0.85
6	Pick and fasten hook to G/W flange	0.818	0.409	**Reduce**	0.409
7	Remove 1 bolt	0.162	0.081	**Simplify**	0.081
8	Remove G/W from machine	0.325	0.325		0.325
9	Unload G/W & remove hook	1.311	1.311		1.311
10	Fix hook to new G/W & move towards M/c	1.809	1.809		1.809
11	Load G/W to m/c	0.153	0.153		0.153
12	Align G/W	1.063	0.266	**Reduce**	0.266
13	Insert 6 Allen screws & just tighten	1.488	0.744	**Combine**	0.897
14	Fully tighten 6 Allen screws	2.100	1.050		
15	Remove hook	0.155	0.039	**Simplify**	0.039
16	Enter Y & Z offset values	8.180	6.135	**Reduce**	6.135
17	Close door & tighten bolts	1.582	0.791	**Simplify**	0.791
18	Fix coolant guard - 1	1.195	0.598	**Simplify**	0.598
	TOTAL TIME		**24.065**		**15.604**

TABLE I. is illustrated in the following pie chart given in Fig. 2 to show the amount of time (in minutes) consumed by the worker before the implementation of the SMED process:


Actual Time (in minutes) consumed by the Worker before the implementation of SMED
0.445
0.622
1.195
0.718
0.15
0.818
0.162
0.325
1.582
1.789
1.311
8.18
1.809
0.153
1.488
1.063
2.1
0.155
Loosen 6 bolts
Remove 6 bolts
Unfasten &remove coolant guard
Open grinding wheel door
Loosen and remove Grinding wheel flange bolts (6nos)
Pick and fasten hook to Grinding wheel flange
Remove 1 bolt
Remove Grinding wheel from machine
Unload Grinding wheel & remove hook
Fix hook to new Grinding wheel & move towards machine
Load Grinding wheel to machine
Align Grinding wheel
Insert 6 Allen screws & just tighten
Fully tighten 6 Allen screws
Remove hook
Enter Y & Z offset values
Close door & tighten bolts
Fix coolant guard - 1
Target time (in minutes) estimated to be consumed on implementation of SMED
0.223
0.359
0.311
0.791
0.598
0.15
0.409
0.85
0.081
0.325
1.311
6.135
1.809
1.05
0.153
0.266
0.039
0.744
Loosen 6 bolts
Remove 6 bolts
Unfasten &remove coolant guard
Open grinding wheel door
Loosen and remove Grinding wheel flange bolts (6nos)
Pick and fasten hook to Grinding wheel flange
Remove 1 bolt
Remove Grinding wheel from machine
Unload Grinding wheel & remove hook
Fix hook to new Grinding wheel & move towards machine
Load Grinding wheel to machine
Align Grinding wheel
Insert 6 Allen screws & just tighten
Fully tighten 6 Allen screws
Remove hook
Enter Y & Z offset values
Close door & tighten bolts
Fix coolant guard - 1

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Time saved (in percent) after the implementation of SMED



- Loosen 6 bolts
- Remove 6 bolts
- Unfasten &remove coolant guard
- Open grinding wheel door
- Loosen and remove Grinding wheel flange bolts (6nos)
- Pick and fasten hook to Grinding wheel flange
- Remove 1 bolt
- Remove Grinding wheel from machine
- Unload Grinding wheel & remove hook
- Fix hook to new Grinding wheel & move towards machine
- Load Grinding wheel to machine
- Align Grinding wheel
- Insert 6 Allen screws & just tighten
- Fully tighten 6 Allen screws
- Remove hook
- Enter Y & Z offset values
- Close door & tighten bolts
- Fix coolant guard - 1

IV. Conclusion

The implementation of SMED on the setup process, reduces the 'total set up time' for the axle grinder from an initial time of **24.065mins** to **14.416 mins (a saving of 58.3% of time)** increasing productivity by **65.38%** / month calculated at 1500 setups in a month with an economic gain to the extent of **53% INR.**

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